Human Health/Human Factors in Trans-Lunar Space

AIAA Space Ops
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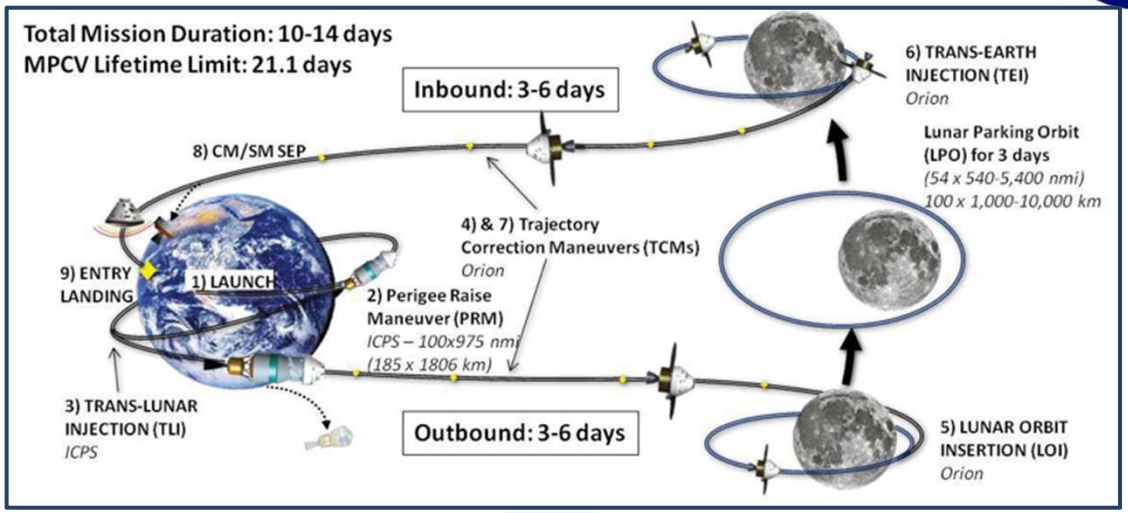
Human Health/Human Factors in Trans-Lunar Space

- Agenda
  - Introduction to Orion and Asteroid Mission
  - Introduction to Orion Habitable Volume
  - Human Systems Integration Design Challenges
    - Stowage
    - Exercise
    - Sleep
    - Meals & Hygiene
    - Adjustments for Asteroid Redirect Crewed Mission (ARCM) Kits
    - Adjustments for ARCM EVAs
    - Contingencies
  - Operational Validation of Designs
  - Conclusion

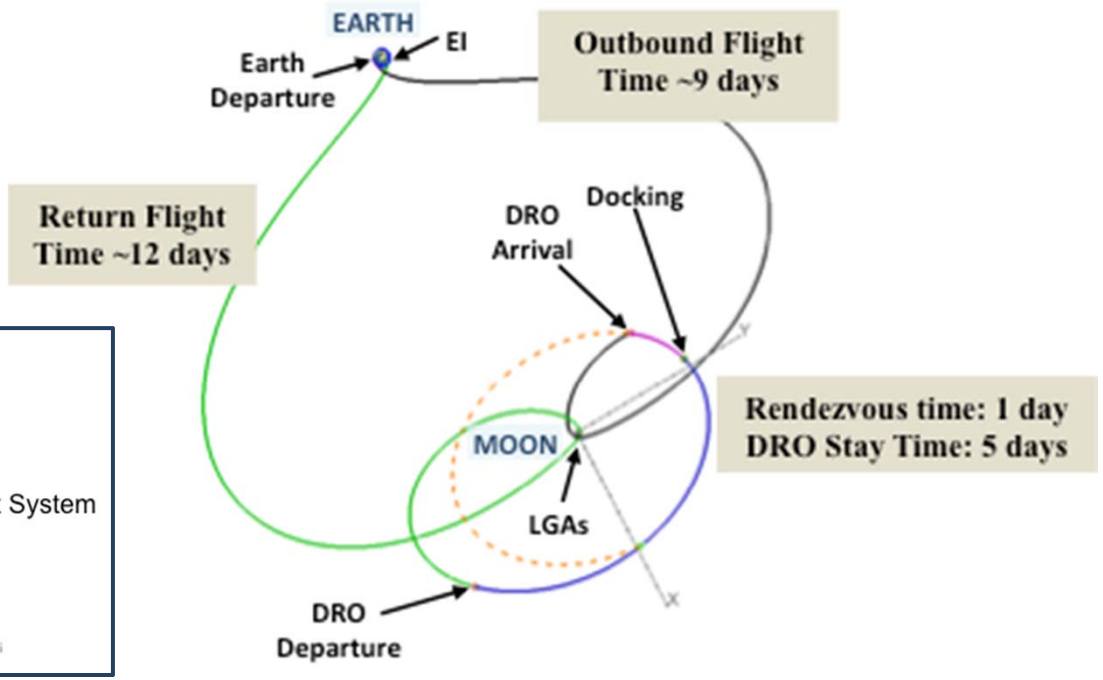
Note: Orion and ARCM concepts presented are still in development

Introduction to Orion and Asteroid Mission

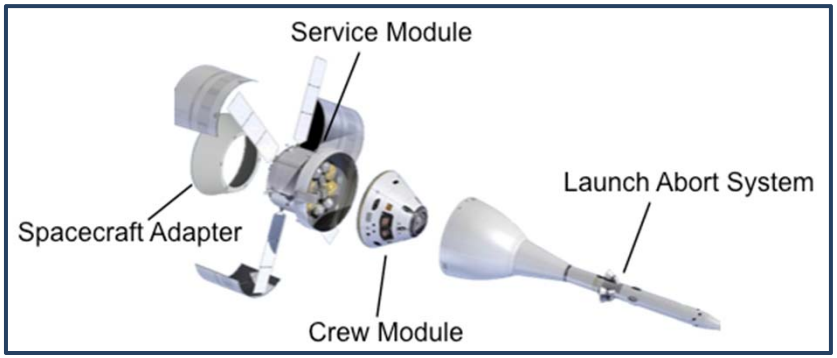
- Orion EM-2 planned mission



- Asteroid Redirect Crewed Mission



- Orion Vehicle

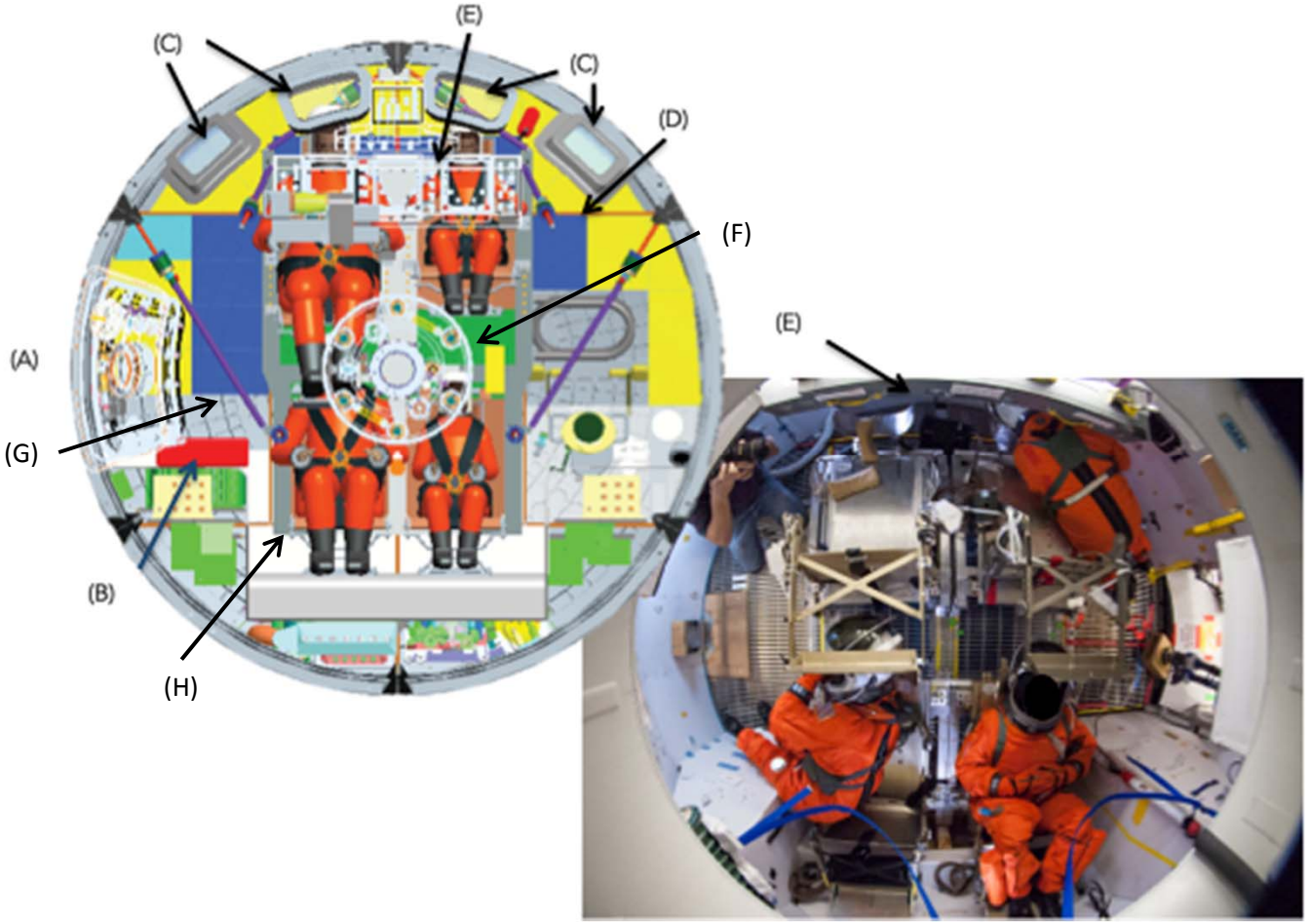


Introduction to Orion Habitable Volume

- Orion Command Module (view from top hatch)

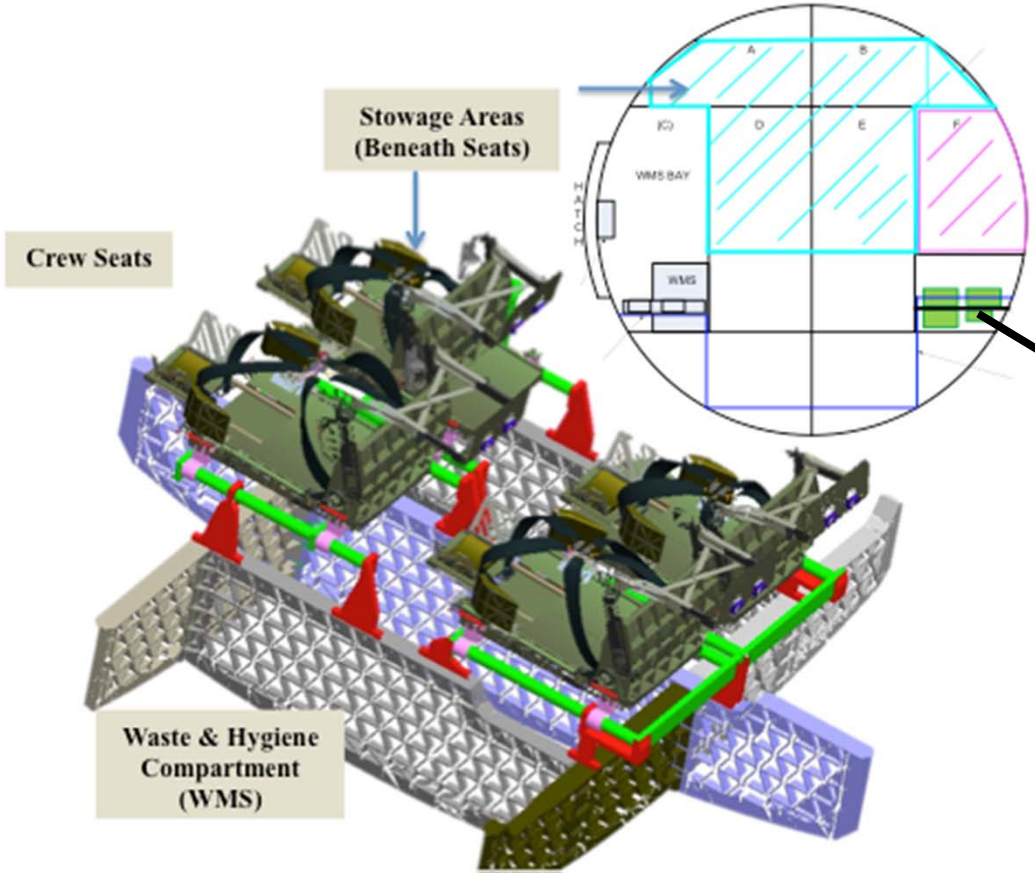
(A) Side Hatch,
(B) Life Raft & Survival Kit Planned Location,
(C) Windows,
(D) Water Dispenser,
(E) Control Panels
(F) Docking Tunnel,
(G) Hygiene Facilities,
(H) Crew Seating

Vehicle	Number of Crew	Duration of Mission	Habitable Volume (m^3)
Orion	4	Up to 21 days	9.4
Orion with ARM	2	Up to 30 days	9.4



Human Systems Integration Design Challenges: Stowage

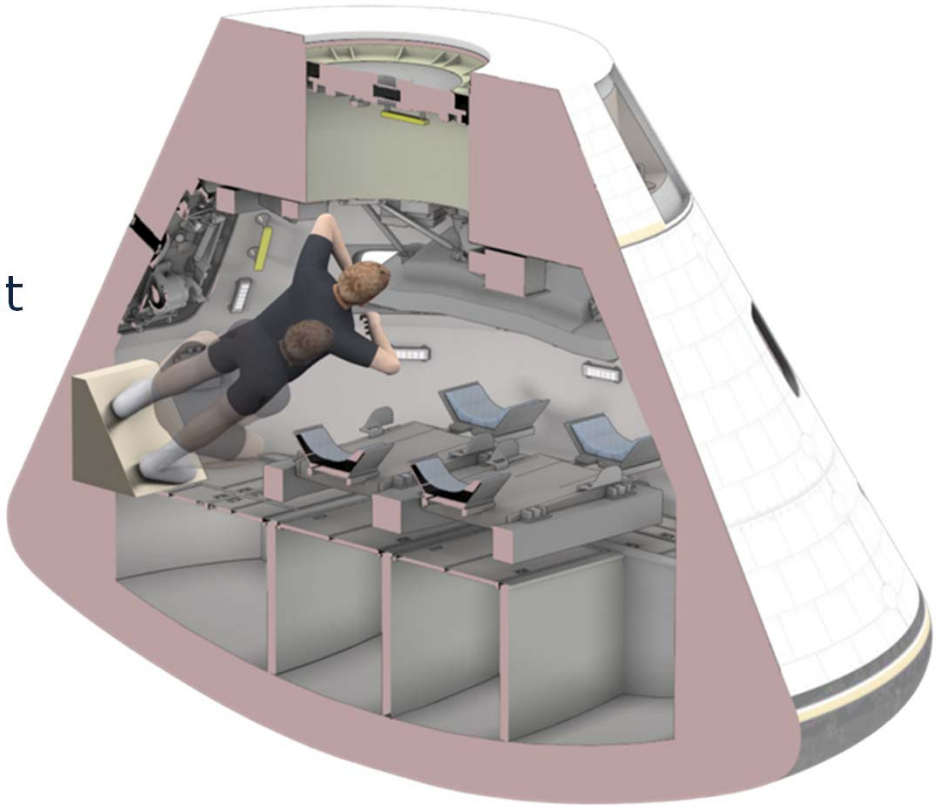
- Planning for stowage
  - Quantifying stowage needed
  - Planning for the dynamics of change during missions (e.g. trash)
  - Planning for accessibility and separation
  - Planning for vehicle mass distribution



Human Systems Integration Design Challenges: Exercise

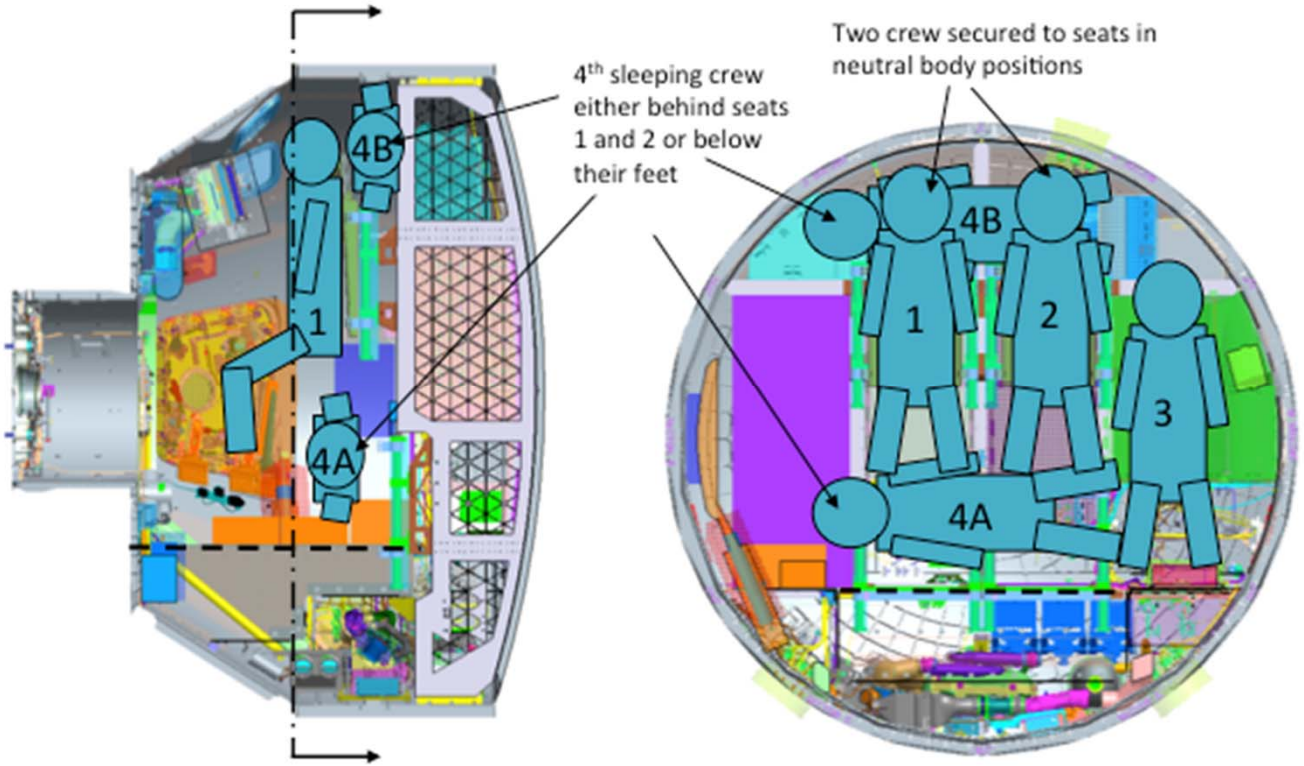
- Summary of physiological deconditioning in space that exercise is used as a mitigation
  - Muscle Loss
  - Aerobic Loss
  - Bone Loss
  - Sensorimotor changes
- Designing for exercise
  - Volume for person movement and hardware
  - Hardware performance characteristics
  - Vehicle driven limitations

  (e.g. mass, atmosphere processing, power, etc.)



Human Systems Integration Design Challenges: Sleep

- Planning for sleep locations
  - Non-interfering sleeping locations
  - Sleeping bag attachments
  - Preventing sleep interruptions from vehicle (e.g. sound, lights, temperature variations, etc.)



Human Systems Integration Design Challenges: Meals & Hygiene

- Designing for meals
  - Food retrieval/rehydration/preparation/disposal
  - Locations for meal activities

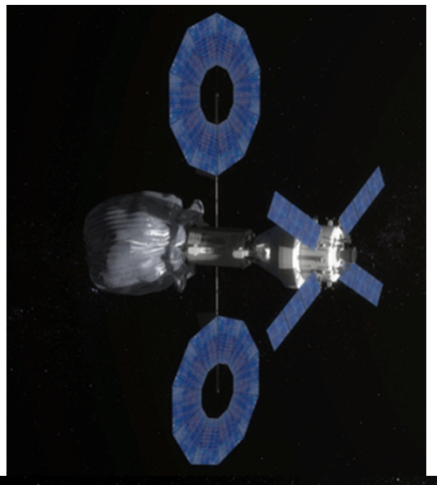
- Hygiene
  - Only personal space in vehicle
  - Support male and female crewmembers

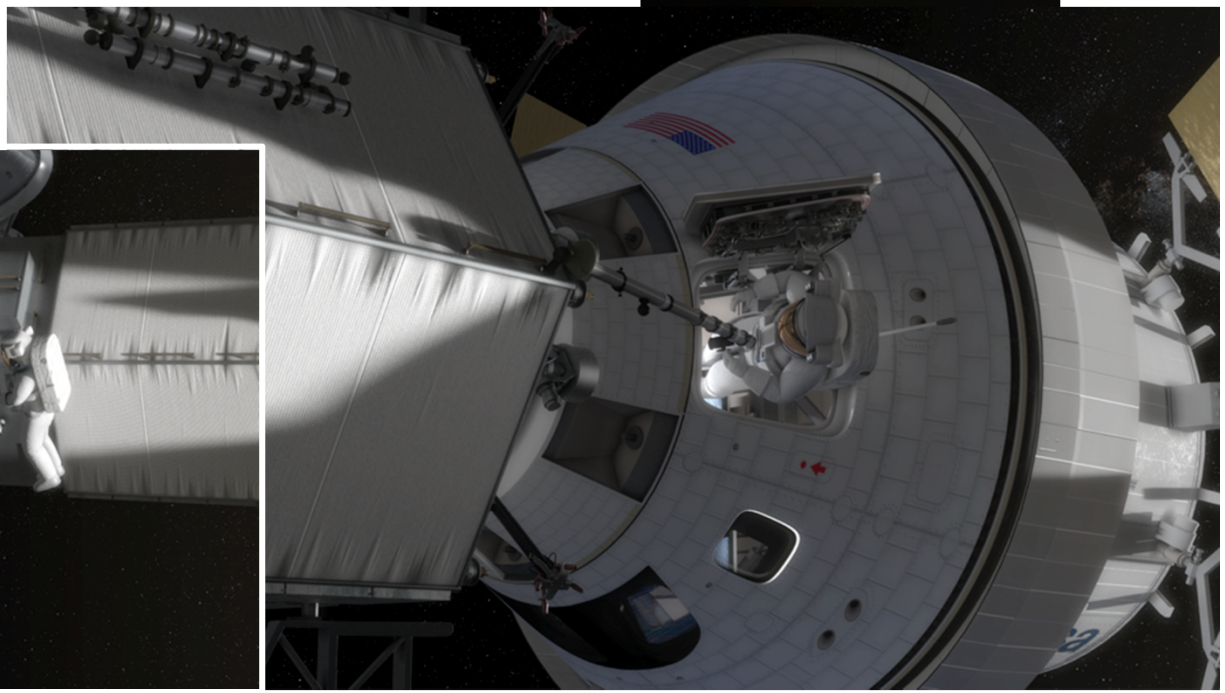
Human Systems Integration Design Challenges: ARCM Kits

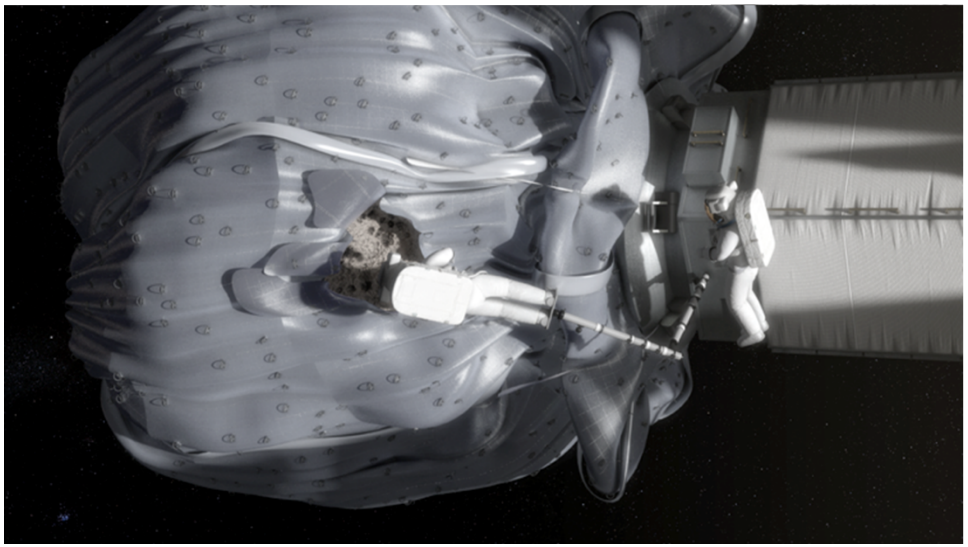
- Adjusting for Asteroid Redirect Crewed Mission (ARCM)
  - 2 Crew
  - Longer mission (adjusted set of consumables)
  - Additional capabilities
    - EVA Suits
    - Science Collection Equipment
    - ARV Docking Equipment
    - Additional Communication Hardware

Human Systems Integration Design Challenges: ARCM EVAs

- Adjusting vehicle designs for asteroid EVAs
  - Adjusting interior volume for safe suit donning and doffing and movement
  - Adjusting interior hardware for vacuum exposure and temperature changes
  - Translation equipment and sampling tools
  - Debris Cleanup

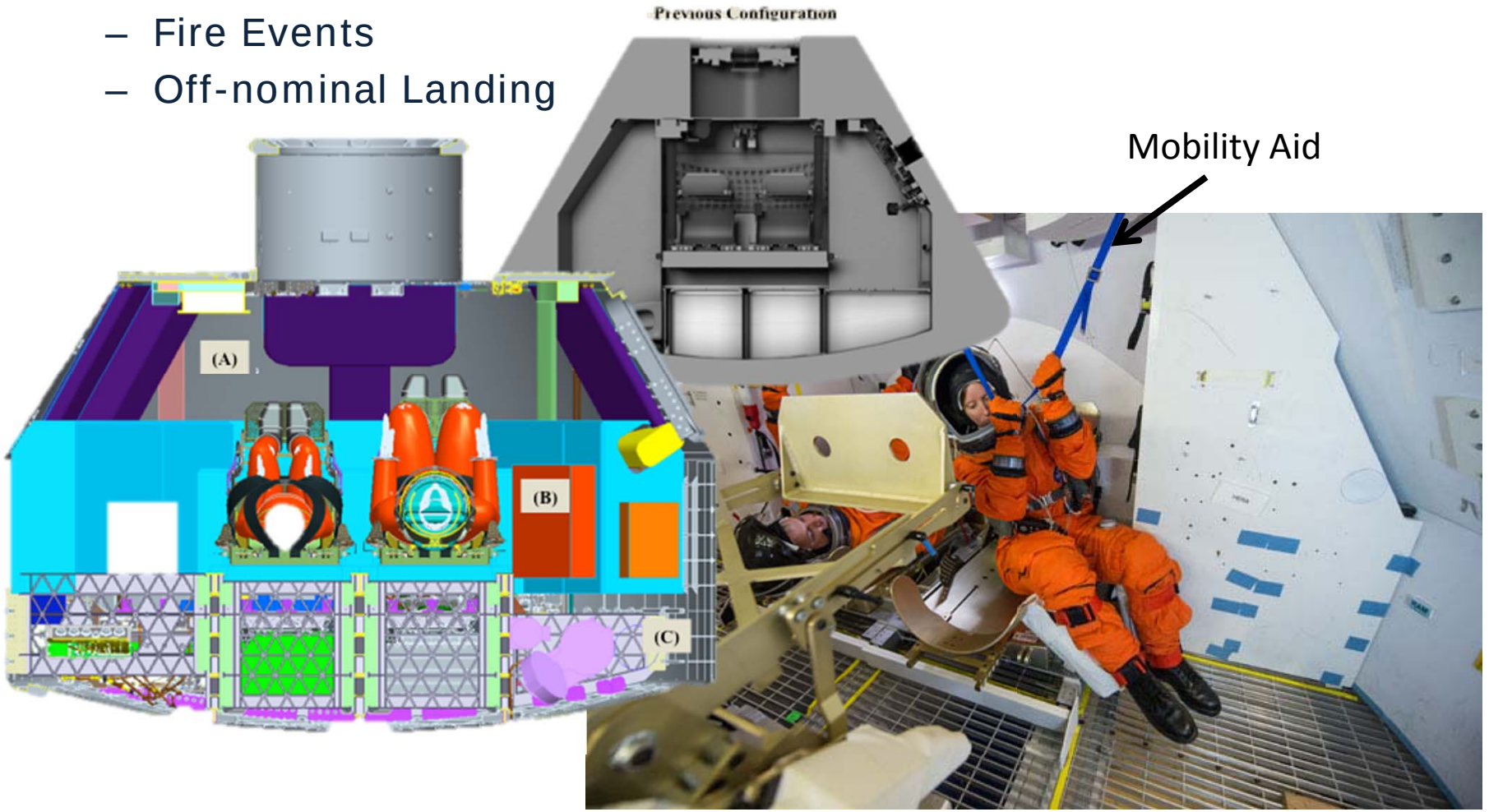






Human Systems Integration Design Challenges: Contingencies

- Contingency Planning and Locations of Supplies
  - Medical Events
  - Radiation Events
  - Fire Events
  - Off-nominal Landing



Operational Validation of Designs

- Approaches used
  - Historical data for parametric assessments
  - Bottoms-up assessments
  - Modeling
  - Human-in-the-Loop testing at various stages of design development
    - Check accessibility
    - Check volumes for different anthropometries
    - Check for obstructions
  - Analog missions using simulated timelines
    - Check for concurrent conflicting activities

NASA's use of "verification" vs. "validation"

Verification = Did the hardware meet the requirement?

Validation = Was the requirement the right requirement?

Conclusion

- Early human systems integration of operational concepts will minimize later costly design changes
- Iterative verifications and validation activities through the design and development process will highlight potential issues in a timely manner
- Consider the time-based changes to vehicle usage
- Orion's small volume for mid-duration missions introduces new operational paradigms
- Asteroid mission introduces new challenges and opportunities in spacecraft design and usage

Any questions?